Executive Function's Role in Children's Perception of Nonnative Speech

Angela Hill[1], Rachael Frush Holt[1], and Tessa Bent[2]
[1]Ohio State University, [2]Indiana University

BACKGROUND

Foreign-Accented Speech

- Foreign-accented speech can differ from native speech along multiple dimensions including phoneme substitutions, deletions, and additions as well as stress, rhythm, and intonation changes (Bent & Holt, 2013)
- Foreign-accented speech requires greater processing time (Munro & Derwing, 1995) and results in poorer word recognition than native speech for adults (Adank et al., 2009) and children (Bent, 2014)

Context

- Although children have more difficulty perceiving speech in noise overall, they show a similar benefit from contextual cues – lexical, semantic, and syntactic – compared to adults (Fallon et al., 2002)
- Nonnative adult listeners do not capitalize on context effects in noise as much as native listeners (Bradlow & Alexander, 2007)

Executive Function

- Executive function encompasses many cognitive processes used to regulate an individual's actions and behaviors, such as inhibition and working memory (Anderson, 2002; Fuster, 1997; Miller & Cohen, 2001; Shallice & Burgess, 1996)
- Executive functions are related to the development of the prefrontal cortex, which occurs into early adulthood (Miller & Cohen, 2001; Stuss & Knight, 2002)
- Executive function has been implicated in speech perception:
  - Difficulties with inhibition, working memory, and auditory attention have been linked to poor spoken language outcomes in children with cochlear implants (e.g., Pisoni et al., 2010)
  - Working memory is related to speech discrimination in normal-hearing toddlers (Holt & Lalonde, 2014)

RESEARCH QUESTIONS

- How does sentence context influence children's recognition of native and foreign-accented speech in noise?
- Does executive function underlie individual differences in children's perception of foreign-accented speech?

METHOD

Participants

	Mean Age	Standard Deviation	Number Females	Number Males
5-year-olds	5.45	0.32	14	14
6-year-olds	6.45	0.29	14	14
7-year-olds	7.47	0.29	14	14

- Monolingual English-speaking children with minimal exposure to Mandarin-accented English (the foreign accent used in this study)
- Parent-reported history of typical speech, hearing, and language
- 3 additional participants were excluded due to parent not completing a questionnaire
- The research was conducted at the Center of Science and Industry (COSI) in Columbus, Ohio

Stimuli

- 60 recorded *English* sentences from the Wildcat Corpus (Van Engen et al., 2010)
  - In half of the sentences, the final (scored) word could be predicted from the sentence context (high predictability)
    - Example: Elephants are big animals
  - In the other half, the final word could not be predicted from the sentence context (low predictability)
    - Example: We pointed to the animals.
  - Each final word appeared twice in the set of sentences: once in low- and once in high-predictability context
- Two male speakers: native English and native Mandarin
- Sentences were embedded in 8-talker babble of +8dB SNR
- 500ms of noise preceded and followed the sentence

Parental Questionnaires

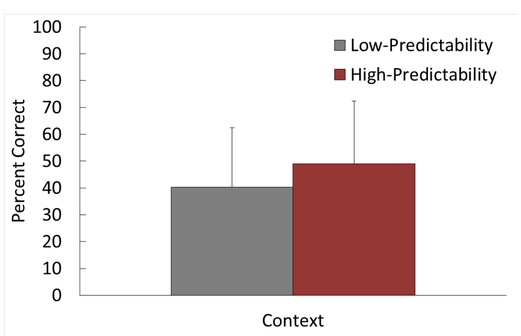
- Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000)
  - Psychometrically rigorous parental report of executive function
  - 86-item questionnaire: caregiver indicates if a list of behaviors were a problem in the last 6 months
  - 8 clinical scales: inhibition, shifting, emotional control, initiation, working memory, planning/organization, organization of materials, and monitoring
- Language background questionnaire including ratings of child's exposure to nonnative speech

Procedure

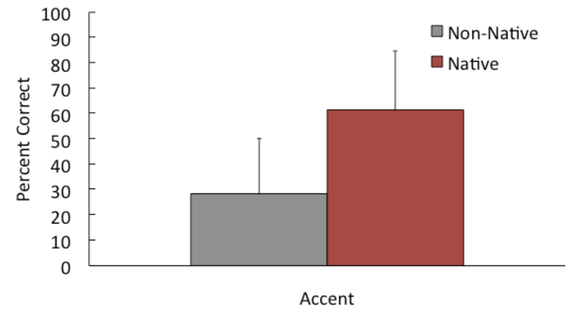
- Data were collected on a Dell Optiplex 790 computer using a custom Python script
- Stimuli were presented through Audio-Technica ETH-770COM headphones in a semi-quiet room
- Sentences were presented at a comfortable listening level
- Participants were randomly assigned to the native-accented condition or the Mandarin-accented condition
- Listeners were asked to repeat each sentence, guessing if necessary
- Before testing began, four practice sentences (two low- and two two-high predictability, one of each accent) were presented

RESULTS

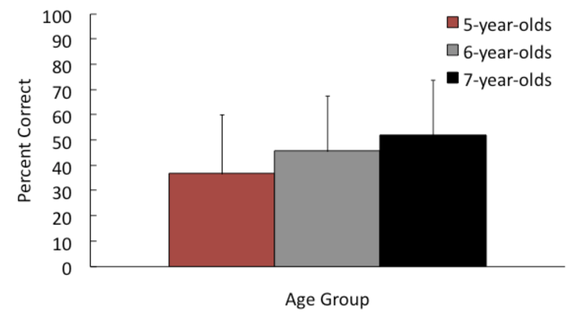
Speech Perception



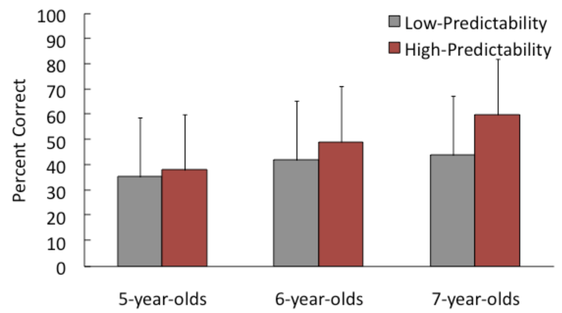
High-predictability words in sentences were identified more accurately than the low-predictability words in sentences, $F(1,78) = 53.793$, $p < 0.0001$.



Words produced by the native speaker were identified more accurately than those by the non-native speaker, $F(1,78) = 95.847$, $p < 0.0001$.

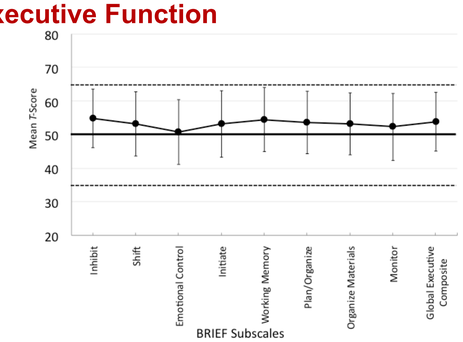


Older children were better at identifying the words in sentences than younger children, $F(2,78) = 6.841$, $p = 0.002$. Post-hoc testing with a conservative Bonferroni correction revealed that 7-year-olds had significantly better recognition accuracy than 5-year-olds ($p = .001$).



The context effect was larger in older children than younger children, $F(2, 78) = 11.032$, $p < .0001$.

Executive Function



Mean *T*-scores (+/- 1SD) on the BRIEF. Higher scores indicate more parent-reported difficulties

Role of Executive Function in Speech Perception

- Spoken word recognition data were collapsed across high- and low-predictability for step-wise linear regression analyses

	B	SE B	Beta
Constant	54.435	12.473	
BRIEF Inhibit	-.495	.232	-.320*

*$p < .05$ $R^2 = .102$

SUMMARY AND DISCUSSION

- Children were able to capitalize on sentence context when presented with foreign-accented speech, extending previous findings for native-accented speech in noise (e.g., Fallon et al., 2002)
- Greater first language experience may facilitate the use of contextual cues: context effects are more beneficial to older children than younger children
  - Similarly, second-language learners are less able to take advantage of context than native listeners, because they have less experience with the target language (Bradlow & Alexander, 2007)
- Parent's rating of children's inhibitory control accounted for ~10% of the variability in children's spoken word recognition scores
  - Inhibitory control involves resisting impulses, stopping one's own behavior at the appropriate time, and *focusing on relevant stimuli in the presence of irrelevant ones*. Example items from the BRIEF include:
    - *Acts wilder or sillier than others in groups (birthday parties, recess)*
    - *Has trouble waiting for turn*
  - Perception of foreign-accented speech in noise requires listeners to focus on relevant cues and inhibit attention to irrelevant ones. Children who have better inhibitory control appear to be better identifying words produced in an unfamiliar accent.
  - Our results support and extend those reported recently from older adults: adaptation to an artificial novel accent could be partially predicted by their selective attention (measured by the flanker task; Janse & Adank, 2012)
    - The task requires the participant to inhibit incorrect responses in incongruent conditions
  - Together, inhibition appears to contribute to individual differences in both children's and adults' perception of unfamiliar accents

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